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HALF-LIFE OF TRITIUM

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Abstract—The body burdens of two tritium luminous dial painters have been followed since the fall of 1967. Urine collections began 6-10 months after termination of work involving occupational exposure to tritium.

In both cases, an intermediate (T_i) and a long (T_l) half-life component could be observed. One individual exhibited a T_i of 21 days and a T_l of 280 days, whereas the second worker showed a T_i of 33 days and a T_l of 2020 days. A surprisingly high seasonal dependence of tritium body water concentration was observed in one case. This resulted in an increase of tritium concentration in body water in winter as compared to the previous summer.

EARLY investigations in humans⁽¹⁾ and animals⁽²⁾ indicated the presence of longer components in the biological half-life of tritium besides the component attributed to the turnover rate of body water (T_w). SNYDER *et al.*⁽³⁾ studied an accident case and found in addition to T_w an intermediate half-life (T_i) of 34 days. REINIG *et al.*,⁽⁴⁾ investigated another accident case and found a third fraction (T_1) of 344 days. Recently another study⁽⁵⁾ was reported for which fractions of 10-30 days and 139-230 days were assigned.

We have been involved in the evaluation of health physics aspects of luminous dial painting. Results of studies dealing with the industrial application, biological half-life, and percutaneous absorption of a tritiated compound have been reported or are in preparation⁽⁶⁻⁸⁾. During these studies it was possible to locate two workers who had been employed by a plant for one or two years and had left the plant for other jobs.

The monitoring of these cases started during the fall of 1967. The subjects were young females, apparently in good health. It was not possible to determine the exact time when the exposure stopped as both workers had worked for several days after the official departure from the plant. The short-term employment occurred, however, three months prior to the first sample collection in both cases. Neither

subject P. B. (age 26 in 1967), nor subject S. K. (age 29 in 1967) has worked in the plant since. Their only connection with the plant was during the interview with us during our visit to the plant in August 1967. The interview occurred in the office of the plant manager where no tritium work is done.

PROCEDURES AND METHODS

It was arranged with these subjects that disposable containers would be sent to them on a bi-weekly basis. The sample collection and shipment were simplified as much as possible to assure the cooperation of the subjects. They were instructed to collect a single voiding early in the morning. In another study it was suspected that improper preservation of urine may have caused erroneous results⁽⁹⁾, so merthiolate was added to the container prior to shipment.

As the first samples in both cases showed a tritium concentration of less than 0.5 $\mu\text{Ci/l.}$, it was clear that a long-term evaluation of the subjects required more sensitive analytical techniques if undistilled urine were to be used. This was necessary as studies with the luminous compound used at the plant where the subjects were employed indicated the possibility of significant errors at certain times after the incorporation of tritium, when the urine was distilled prior to liquid scintillation counting.

The analysis was carried out by a newly developed liquid scintillation method either direct⁽¹⁰⁾ or by oxidative distillation⁽¹¹⁾ of urine using potassium persulfate. All samples were run in duplicate. The minimum limit of detection of the direct technique was 10 nCi/l. and the corresponding limit for the method using distillation was 0.2 nCi/l.

The first ten samples were analyzed by both liquid scintillation techniques and the results agreed in each case within statistical counting error at the 2σ confidence level. This indicated the oxidative distillation could be used at activity levels which would require a distillation to assure a reasonable accuracy.

The results reported in this paper have a counting error of less than 5% at the 2σ confidence level. The total error associated with results is estimated to be less than 10%.

The drinking water at the geographical location of these subjects contained 0.8 nCi/l. at the beginning of this study and 0.4 nCi/l. during June 1969. These levels would not significantly affect the body burden of the subjects.

RESULTS AND DISCUSSIONS

Tritium concentrations of urine samples collected from both subjects are shown in Tables 1 and 2.

Table 1. Tritium concentration in urine samples from P. B. female age 26 (1967)

Date	Day	(nCi/l.)	Date	Day	(nCi/l.)
9/27/67	0	380	9/18/68	357	43
10/25/67	28	214	10/07/68	376	48
12/18/67	82	111	10/25/68	394	37
1/19/68	114	86	11/04/68	404	41
1/31/68	126	74	11/15/68	415	59
2/26/68	152	61	11/25/68	425	51
3/08/68	163	67	12/16/68	446	61
4/18/68	204	50	12/27/68	457	67
5/06/68	222	54	1/30/69	491	63
5/13/68	229	48	2/13/69	505	69
6/05/68	252	45	2/24/69	516	61
6/13/68	260	41	3/04/69	524	61
6/27/68	274	42	4/01/69	552	67
7/25/68	302	39	5/09/69	590	44
7/29/68	306	41	6/10/69	622	32
8/29/68	337	43	6/20/69	632	20
9/10/68	349	45			

Table 2. Tritium concentration in urine samples from S. K. female age 29 (1967)

Date	Day	(nCi/l.)	Date	Day	(nCi/l.)
9/27/67	0	252	7/15/68	292	8.5
10/25/67	28	128	7/24/68	301	10
11/21/67	55	52	8/28/68	336	12
12/20/67	84	29	9/18/68	357	8.8
1/26/68	121	25	10/02/68	371	8.2
2/23/68	149	23	10/16/68	383	9.0
3/14/68	169	20	10/28/68	395	7.2
3/28/68	183	18	11/15/68	413	8.0
4/18/68	204	16	12/02/68	430	8.8
5/03/68	219	12	12/16/68	444	14
5/23/68	239	10	1/08/69	467	7.2
6/07/68	254	11	2/05/69	495	8.0
6/20/68	267	9.0			

Figures 1 and 2 show the results plotted and a least square fit made according to the program proposed by RICHMOND.⁽¹²⁾

The equations describing the cases are:

$$C_{P.B.} = 3.2e^{-0.693t/33} + 0.5e^{-0.693t/2020}$$

$$C_{S.K.} = 2.3e^{-0.643t/21} + 0.2e^{-0.693t/280}$$

The intermediate half-lives of 33 and 21 days agree well with those reported by Snyder (30 days) and Reinig (23.4 days). Also the

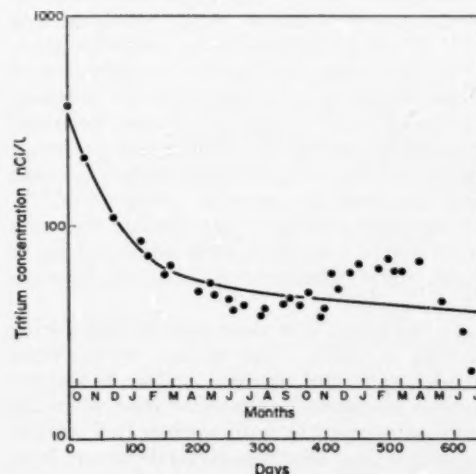


FIG. 1. Tritium concentration in urine of the subject P. B.

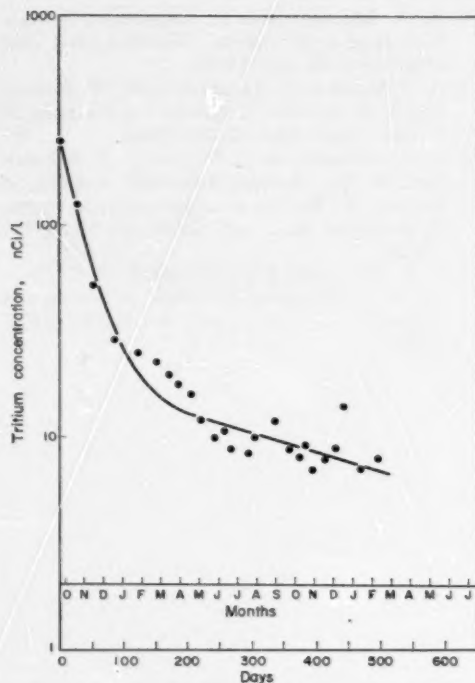


FIG. 2. Tritium concentration in urine of the subject S. K.

280 days agree reasonably well with 344 days reported by Reinig *et al.*

The case of P. B. is, however, striking. While the initial decrease in body burden follows an exponential function, the second fraction (T_2) deviates considerably from such a pattern. It can be seen that the concentration of tritium in body water actually increased considerably at certain times although no tritium intake had occurred. A closer evaluation of the data reveals a seasonal variation of body burden, i.e. an increase in winter and a decrease in summer. The hot climate of the geographical location of the subjects (Athens, Georgia) may have influenced this behavior. At this location hot summers are common. It is possible that increased water intake during summer has diluted the tritium which is located in the tissues and constantly released into the body water.

This explanation does not account for a different behavior of S. K. who showed a

reasonably constant excretion rate. This may be attributed to differences in metabolism and water intake of these subjects although the influence of other factors cannot be excluded. The accident case, reported by Reinig *et al.*, also shows an increase similar to the one exhibited by P. B., although these authors did not follow the subject long enough to find such a pronounced effect as shown by P. B.

The long effective half-life of 2020 days can be regarded as an approximation. Additional data may change this T_1 in either direction. There is, however, no question that a fraction of the biological half-life of tritium is long and should be more seriously considered than heretofore.

A dose assessment of these cases is impossible. There is no information regarding the initial decrease in body burden which undoubtedly occurred with a half-life of approximately 10 days. It is also difficult to establish the beginning of T_1 in each case as the first samples received were already decreasing with this half-life.

The present results do not permit any judgment with respect to size of the metabolic pool for each one of these components.

The subject S. K. has recently gone back to work with tritium and thus can no longer be followed.

No sample was received from P. B. from June to December 1969. As this subject has expressed a willingness to submit samples again, it is planned to continue the evaluation of this subject as long as possible.

REFERENCES

1. E. A. PINSON and W. H. LANGHAN, Physiology and toxicology of tritium in man. *J. appl. Physiol.* **10**, 108 (1957).
2. R. C. THOMPSON, Studies of metabolic turnover with tritium as a tracer II. Gross studies on the rat. *J. biol. Chem.* **200**, 731 (1952).
3. W. S. SNYDER, B. R. FISH, S. R. BERNARD, M. R. FORD and J. R. MUIR, Urinary excretion of tritium following exposure of man to HTO—A two exponential model. *Phys. Med. Biol.* **13**, 547 (1968).
4. S. M. SANDERS and W. C. REINIG, Assessment of tritium in man. *Diagnosis and Treatment of Deposited Radionuclides*, p. 534. Excerpta medica Foundation (1968).

5. W. MINDER, Internal contamination with tritium. *Strahlentherapie* **137**, 700 (1969).
6. A. A. MOGHISSI, E. D. TOERBER, J. E. REGNIER, M. W. CARTER and C. D. POSEY, Health physics aspects of tritium luminous dial painting. *Health Phys.* **18**, 255 (1970).
7. J. K. WHEELER, A. A. MOGHISSI, B. F. REHNBERG and M. C. COLVIN, Comparison between the biological half-life of a tritiated luminous compound with that of tritiated water *Health Phys.* (in press).
8. B. F. REHNBERG, A. A. MOGHISSI, J. K. WHEELER and M. C. COLVIN, Percutaneous absorption of tritium from a luminous compound by rats *Health Phys.* (in press).
9. A. A. MOGHISSI and R. LIEBERMAN, Tritium body burden of children 1967-1968. *Rad. Illth Data Reports* **11**, 227 (1970).
10. A. A. MOGHISSI, R. LIEBERMAN, M. W. CARTER and J. E. REGNIER, Improved radiobioassay of tritium. *Health Phys.* **17**, 727 (1969).
11. A. A. MOGHISSI, H. L. KELLEY, J. E. REGNIER and M. W. CARTER, Low-level counting of tritium. I. Tritium measurement in homogeneous systems. *Int. J. appl. Radiat. Isotopes* **20**, 145 (1969).
12. C. R. RICHMOND, J. E. FURCHNER, P. N. DEAN and P. McWILLIAMS, Electronic processing and analysis of metabolic data. *Health Phys.* **10**, 3 (1964).